

PTO 10-2484

CC=JP DATE=20030520 KIND=A
PN=2003145290

COMPOSITE MATERIAL FOR BRAZING AND BRAZING STRUCTURE
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UNITED STATES PATENT AND TRADEMARK OFFICE
Washington, D.C. February 2010

Translated by: FLS, Inc.

PUBLICATION COUNTRY	(19):	JP
DOCUMENT NUMBER	(11):	2003-145290
DOCUMENT KIND	(12):	A
PUBLICATION DATE	(43):	20030520
APPLICATION NUMBER	(21):	2001-344290
DATE OF FILING	(22):	20011109
ADDITION TO	(61):	
INTERNATIONAL CLASSIFICATION	(51):	B23K 35/14, 1/20; C22C 9/00, 9/01, 9/05, 19/05; F28F 21/08 // B23K101:14
PRIORITY	(30):	
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DESIGNATED CONTRACTING STATES	(81):	
TITLE	(54):	COMPOSITE MATERIAL FOR BRAZING AND BRAZING STRUCTURE
FOREIGN TITLE	[54A]:	ROSETSUYO HUKUGOZAI OYOB I ROSETSU KOZO

[Claims]

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[Claim 1] Composite material for brazing which comprises a base plate made from corrosion resistant steel material and has Fe-atom-diffusion-suppressing layer laminated on the surface of said base plate for suppressing diffusion of Fe atoms from said base plate to the brazing filler metal side when joining member is brazed with Cu-based brazing filler metal of pure Cu or Cu-group alloy having Cu as the main element. Here, said Fe-atom-diffusion-suppressing layer is made from Ni-Cr alloy with chief ingredient of Ni and containing 10~30 mass% of Cr.

[Claim 2] The composite material for brazing according to Claim 1, where a brazing filler metal layer made from above-mentioned brazing filler is laminated on top of said Fe-atom-diffusion-suppressing layer.

[Claim 3] The composite material for brazing according to Claim 1 or Claim 2, wherein said Cu-based brazing filler metal is formed from Al-added Cu-group alloy having Cu as the chief ingredient and containing 1~5 mass % of Al.

[Claim 4] The composite material for brazing according to one of Claim 1 through 3, wherein the thickness of said Fe-atom-diffusion-suppressing layer is 5 μm or more.

[Claim 5] Brazing structure comprising the first joining member having a base plate formed from corrosion resistant steel material and a second joining member having a base plate formed from corrosion resistant steel material and brazed to said first joining member via the brazing filler metal, where said first joining member has a

* Claim and paragraph numbers correspond to those in the foreign text.

Fe-atom-diffusion-suppressing layer which suppresses Fe atoms to diffuse to the brazing filler metal part from the base plate of the first joining member when the second joining member is brazed, wherein the Fe-atom-diffusion-suppressing layer is formed from Ni-Cr alloy having Ni as the chief ingredient and containing 10~30 mass % of Cr, wherein the brazing filler metal is formed from Cu-Ni-Cr alloy having Cu as the chief ingredient and containing 15~25 mass % of Ni, and 10~15 mass % of Cr.

[Claim 6] Brazing structure comprising the first joining member having a base plate formed from corrosion resistant steel material and a second joining member having a base plate formed from corrosion resistant steel material and brazed to said first joining member via the brazing filler metal, where said first joining member has a Fe-atom-diffusion-suppressing layer which suppresses Fe atoms to diffuse to the brazing filler metal part from the base plate of the first joining member when the second joining member is brazed, wherein the Fe-atom-diffusion-suppressing layer is formed from Ni-Cr alloy having Ni as the chief ingredient and containing 10~30 mass % of Cr, wherein the brazing filler metal is formed from Cu-Ni-Cr-Al alloy having Cu as the chief ingredient and containing 15~25 mass % of Ni, 8~15 mass % of Cr, and 1~5 mass % of Al.

[Claim 7] The brazing structure according to Claim 5 or 6, wherein a flow passage is formed between said first joining member and said second joining member from these joining members.

[Claim 8] The brazing structure according to one of Claim 5 through

7, wherein said second joining member has Fe-atom-diffusion suppressing layer which suppresses Fe atoms from diffusing to the brazing filler metal part from the base plate of the second joining member when the first joining member and the second joining members are brazed.

[Detailed description of the invention]

[0001] [Technical field of the invention]

This invention is related to brazing structure suitable for flow passage of heat exchanger for radiator, gas cooler, and the like, and is related to composite material for brazing that is used as raw material for the structure.

[0002] [Prior art]

More lately, environmental issues have attracted international attention, and as one consequence of it, there is a strong demand for cleaning up exhaust gas of automobile. As means to clean automobile exhaust gas, various commercially available cleaning devices have been introduced such as a thermal reactor and catalytic converter that reheats exhaust gas and converts CO and HC into CO₂ and H₂O. Conventionally, heat exchanger used in an atmosphere of high-temperature corrosive gas cleaning device, which is used by exhaust gas cleaning device and the like, is created by brazing the joining member made from corrosion resistance stainless steel material with Cu-based brazing filler metal. For said Cu-based brazing filler metal, copper brazing filler with melting point of 1000°C and with excellent corrosion resistance, or brazing filler metal disclosed in JP-A (Tokkai) S60-072695 containing 5~20% of Mn and 1~5% of Ni and remaining balance of Cu, have been used.

[0003] Recently, with changes in exhaust gas composition, corrosive environment in heat exchanger has become even more severe. There are also problems, such as corrosion from condensate liquid of exhaust gas. For this reason, further improvement in corrosion resistance is demanded of the brazed member, which is created by joining two joining members with brazing filler metal, making up the flow passage of the heat exchanger. In response to such demand, as was disclosed in W000/45987, we have prosed constructing flow passage structure of heat exchanger from a stainless steel base plate laminated with Fe-atom-diffusion-suppression layer made from pure Ni or Ni-base alloy with chief ingredient of Ni, and using composite material for brazing laminated with brazing filler metal layer of pure Cu or Cu-base alloy with chief ingredient of Cu and joining member material that uses this composite material. With this composite material for brazing, Fe-atom-diffusion-suppressing layer suppresses diffusion of Fe atoms to brazing material from the stainless steel material during brazing process, and appropriate amount of Ni would diffuse from Fe-atom-diffusion-layer to brazing filler metal part to form Cu-Ni alloy, which in turn improves corrosion resistant characteristics of the brazing filler metal.

[0004] [Problems to be resolved by the invention]

As stated above, it was possible to improve corrosion resistance of brazing filler metal of heat exchanger by using composite material for brazing comprising Fe-atom-diffusion-suppressing layer. However, with respect to heat exchanger which performs heat exchange of high-temperature exhaust gas, subsequent study has revealed that simply improving the

corrosion resistance of the brazing filler metal is not sufficient to obtain durability and that it would adversely affect the overall processing system mounted with the heat exchanger. In other words, when the fluid, such as exhaust gas, to be heat exchanged is high-temperature corrosive fluid, insufficient oxidation resistance of the brazing filler metal would not only cause deterioration of bonding strength due to oxidation depletion of the brazing filler metal, but also it would cause the oxide layer to peel off from the surface of the brazing filler metal and to flow to downstream side of the heat exchanger, contaminating and damaging various processing devices located in the downstream side, and the performance would suffer.

[0005] This invention addresses these problems and aims to provide material for brazing that can add excellent corrosion resistance and oxidation resistance to the brazing filler metal part, to be used in the brazed structure of flow passage structure of heat exchanger and the like, as well as to provide brazed structure with excellent corrosion resistance and oxidation resistance in the brazing filler metal part.

[0006] [Means for solving the problem]

The composite material for brazing of this invention comprises a base plate made from corrosion resistant steel material and has Fe-atom-diffusion-suppressing layer laminated on the surface of said base plate for suppressing diffusion of Fe atoms from said base plate to the brazing filler metal side when joining member is brazed with Cu-based brazing filler metal of pure Cu or Cu-group alloy having Cu as the main element. Here, said Fe-atom-diffusion-suppressing layer is formed from

Ni-Cr alloy with chief ingredient of Ni and containing 10~30 mass % of Cr. From here on, components will be expressed with simple %.

[0007] With this composite material, since the base plate has laminated Fe-atom-diffusion-suppressing layer, the brazing filler metal part of brazed structure using this composite material would be protected by Fe-atom-diffusion-suppressing layer which suppresses Fe atoms from diffusing from the base plate to the brazing filler metal part during brazing process. This would prevent deterioration in the corrosion resistance characteristics of the brazing filler metal part. Further, since the Fe-atom-diffusion-suppressing layer is formed from Ni-Cr alloy containing prescribed amount of Cr, its Ni and Cr would diffuse from the Fe-atom-diffusion-suppressing layer to the brazing filler metal part during the brazing process, which can form Cu-Ni-Cr alloy, containing 15~25% of Ni and 10~15% of Cr, in the brazing filler metal part. Said Cu-Ni-Cr alloy can further improve the corrosion resistance of the brazing filler metal part, and said Cr forms Cr oxidized film on the surface of the brazing filler metal part, improving its oxidation resistance. For this reason, it is possible to provide excellent corrosion resistance and oxidation resistance to the brazing filler metal part of the brazed structure.

[0008] One of favorable feature of said composite material for brazing is that it is possible to laminate the brazing filler metal layer created from said Cu brazing filler metal on top of said Fe-atom-diffusion-suppressing layer. By integrating the brazing filler metal layer, there is no need to prepare separate brazing filler metal

during brazing the joining member, and can improve the workability of brazing process.

[0009] Further, one favorable aspect of said composite material for brazing is that it is possible to form the Cu brazing filler metal from the Cu-group alloy with the main ingredient of Cu and containing 1~7% of Al. By using such Cu-group alloy containing Al, an Al oxidized film is formed in the lower side of the Cr oxidized film. This double layer of oxidized films can significantly improve the corrosion resistance.

[0010] It is better to make the thickness of the Fe-atom-diffusion-suppressing layer of said composite material for brazing at least 5 μm or more. With 5 μm or more thickness, it is possible to sufficiently suppress Fe atoms of the base plate to invade the brazing filler metal part through solid-phase diffusion of the Fe-atom-diffusion suppressing layer, and to sufficiently prevent deterioration of corrosion resistance due to diffusion and invasion of Fe atoms into the brazing filler metal.

[0011] The brazing structure of this invention comprises the first joining member having a base plate formed from corrosion resistant steel material and a second joining member having a base plate formed from corrosion resistant steel material and brazed to said first joining member via the brazing filler metal, where said first joining member has a Fe-atom-diffusion-suppressing layer which suppresses Fe atoms to diffuse from the base plate of the first joining member to the brazing filler metal part when the second joining member is brazed, wherein the Fe-atom-diffusion-suppressing layer is formed from Ni-Cr alloy having

Ni as the chief ingredient and containing 10~30 mass % of Cr, wherein the brazing filler metal is formed from Cu-Ni-Cr alloy having Cu as the chief ingredient and containing 15~25 % of Ni, and 10~15 % of Cr.

[0012] With this brazing structure, the first joining member is formed from the base plate laminated with Fe-atom-diffusion-suppressing layer of Ni-Cr alloy containing the essential ingredient of Cr. Thus, when the second joining member is brazed, it is possible to suppress the Fe atoms in the baseplate of the first joining member from diffusing and invading the brazing filler metal part. Further, diffusion of Ni and Cr from the Fe-atom-diffusion-suppressing layer would create alloy from prescribed amount of Ni and created Cr oxidized film from prescribed amount of Cr. This would add excellent corrosion resistance and oxidation resistance to the brazing filler metal. Thus, the brazing structure would possess an excellent durability.

[0013] In said brazing structure, the brazing filler metal should be formed from Cu-Ni-Cr-Al alloy having Cu as its main ingredient and containing 15~25% of Ni, 8~15% of Cr, and 1~5% of Al. By including prescribed amount of Al in the brazing filler metal, it is possible to form compound Al oxidized film below Cr oxidized film, which would further improve the oxidation resistance. In order to include prescribed amount of Al in the brazing filler metal, one should use Cu-group alloy with chief ingredient of Cu with Al additive, containing 1~5% of Al, for Cu brazing filler metal used for brazing.

[0014] In above-mentioned brazing structure, it is possible to form a flow passage between said first joining member and second joining member

from these joining member materials. By forming such flow passage, it is possible to flow the fluid to be heat exchanged or medium to be heat exchanged in this flow passage, providing flow passage structure of heat exchanger with excellent durability. Further, it is possible to prevent adverse effect from peeled oxidized film on the devices deployed in the downstream side of the flow passage.

[0015] In above-mentioned brazing structure, said second joining member, just like said first joining member, could have a Fe-atom-diffusion suppressing layer which suppresses Fe atoms from diffusing to the brazing filler metal part from the base plate of the second joining member when the first joining member and the second joining members are brazed. This Fe-atom-diffusion-suppressing layer could be made from said Ni-Cr alloy. With this, it is possible to prevent Fe atoms from the second joining member to diffuse and invade the brazing filler metal, and can improve the performance of brazing of the second joining member.

[0016] [Embodiments]

Figure 1 shows a composite material for brazing 1 under one embodiment of this invention, where a Fe-atom-diffusion-suppressing layer 12 is laminated on one side of the base plate 11 in a plate shape, and the brazing filler metal layer 13 is laminated on top of it. Since this composite material for brazing has a brazing filler metal layer 13 laminated on top of the Fe-atom-diffusion-suppressing layer 12, it is not necessary to take additional step to add separately prepared brazing filler metal between the target joining member materials during the brazing process. This would provide an excellent workability of brazing process.

[0017] Said base plate 11 is made from iron steel material with good corrosion resistance, namely from stainless steel material such as SUS 304 and SUS 316 austenite stainless steel under JIS specification, and SUS 430 and SUS 434 ferrite stainless steel.

[0018] Above-mentioned Fe-atom-diffusion-suppressing layer 12 is formed from Ni-Cr alloy with Ni as the chief ingredient and containing 10~30%, more favorably 15~25%, of Cr. This Ni-Cr alloy does not contain Fe, and its melting point is higher than the melting point of Cu brazing filler metal making up the brazing filler metal layer 13. Further, Ni and Cr melts with Cu, the chief ingredient of said brazing filler metal. Therefore, this Ni-Cr would not produce deposit material that could trigger corrosion. Said Ni-Cr alloy is typically made up from Cr, the key ingredient, and balance of Ni and unavoidable impure atoms. However, as long as such atoms can melt with Ni, would not hamper workability of Ni-Cr alloy, and would not deteriorate the brazing filler metal characteristics after the brazing, addition of such atoms in minute quantity is permitted.

[0019] Said Ni-Cr alloy improves the corrosion resistance of the brazing filler metal since about 15~15% of Ni is diffuses and solid-solves into the brazing filler metal part as the brazing filler layer 13 melts during the brazing process. On the other hand, 10%15% of Cr diffuses and sold-solves into said brazing filler metal to create Cr oxidized film on its surface and improves corrosion resistance. If Cr is contained by less than 10% in said Ni-Cr, it is difficult to obtain an appropriate amount of Cr diffusion into the brazing filler metal, which would lower the corrosion resistance of the brazing filler metal. On the other hand,

if the percentage exceeds 30%, it would hamper workability and would produce excessive diffusion to the brazing filler metal. As the result, the amount of Cr in the brazing filler metal would exceed 15%, causing segregation of Cr easily, and reduce corrosion resistance. For these reason, the amount of Cr contained in the Ni-Cr alloy, which forms the Fe-atom-diffusion-suppressing layer 12, should be 10~30%, or more favorably 10~25%, and most favorably 15~25%.

[0020] The thickness of said Fe-atom-diffusion-suppressing layer 12 should be 5 μ m or more, or more favorably 8 μ m or more, and even more favorably 10 μ m or more. When above-mentioned composite material for brazing is used in brazing process, the brazing temperature is said to be about 1100~1250°C as mentioned later. Even at this high temperature, it is possible to obtain diffusion suppressing effect of Fe atoms to some extent with about 5 μ m thickness during brazing process. It is possible to completely prevent Fe atom diffusion to brazing filler metal with about 10 μ m thickness.

[0021] Above-mentioned brazing filler metal layer 13 is formed from Cu brazing filler metal made from pure Cu or Cu-group alloy containing Cu as its chief ingredient. As above-mentioned Cu-group alloy, Cu-Ni alloy or Cu-Mn-Ni alloy whose component element takes on complete solid-solution state. Cu content should be about 85% or more. In above-mentioned Cu-Ni alloy, it should contain 15% or less of Ni with the basic element of Cu for the balance. If Ni exceeds 15%, the melting point of the brazing filler metal would increase and would make the brazing work more difficult. In above-mentioned Cu-group alloy, minute amount of atoms could be added

as long as they melt with Cu, and would not hamper workability of the brazing filler metal and brazing filler metal characteristics after the brazing.

[0022] As for above-mentioned Cu brazing filler metal, Al added Cu-group alloy containing 1~5% of Al, or more favorably 2~4% of Al, is desirable. By adding Al, an Al oxidized film would be created on the lower side (brazing filler metal side) of the Cr oxidized film formed on the surface of the brazing filler metal created by brazing process. This would form 2 layers of oxidized films, which would significantly improve corrosion resistance. If amount of Al is less than 1%, formation of Al oxidized film is difficult, while if it exceeds 5%, Al added Cu-group alloy is difficult to work with, and such material would not be used as brazing filler metal. If Al added Cu-group alloy is used as the brazing filler metal, the corrosion resistance is improved significantly from Al effect, it is possible to obtain sufficient corrosion resistance by setting the content of Cr at 8~15% in the brazing filler metal. Above-mentioned Cr oxidized film and Al oxidized film can be verified by EPMA.

[0023] In order to laminate Fe-atom-diffusion-suppressing layer 12 on said base plate 11, normally a cladding method by pressure welding is used. It is also possible to use other methods such as plating, thermal spraying, PVD, and CVD. By cladding the base plate 11 and the Fe-atom-diffusion-suppressing layer 12 by pressure welding, no pinholes would be created that could cause problem with plating, both can be integrated easily, and would improve factory production performance.

Further, the thickness of the Fe-atom-diffusion-suppressing layer 12 could easily be controlled by adjusting the rolling reduction of the pressure welding. The brazing filler metal layer 13 is normally welded on the Fe-atom-diffusion-suppressing layer 12 laminated on the base plate 11 by pressure welding. When 3 layers are to be bonded by pressure welding, stack the base plate 11, Fe-atom-diffusion-suppressing layer 12, and the brazing filler metal layer 13, pressure weld them, and if needed, anneal them.

[0024] If above-mentioned composite material for brazing is used, the brazing temperature should be equal to or higher than melting point of Cu brazing filler metal and less than melting point of the metal forming Fe-atom-diffusion-suppressing layer. Normally, this temperature is around 1100~1250°C, and preferably around 1150~1200°C. If it is less than 1100°C, Ni and Cr take too much time to diffuse to brazing filler metal part from Fe-atom-diffusion-suppressing layer, hampering productivity. On the other hand, if the temperature is above 1250°C, it is unnecessarily high and causes severe damage to the heating furnace; or, it requires very expensive furnace with extremely excellent heat resistance. In either case, this would not be suitable for industrial production. The holding time at the brazing temperature of 10~50 minutes would be sufficient if the temperature is around 1100~1250°C. During this holding time of the temperature during brazing process, when the composite material for brazing filler metal is worked into appropriate shape, its base plate 11 is annealed at the same time.

[0025] Thus far, we have explained the composite material for brazing

of this invention. However the interpretation of this invention is not to be limited by this embodiment. For example, in above embodiment, Fe-atom-diffusion-suppressing layer 12 and the brazing filler metal layer 13 were laminated on one side of the base plate 11. If, on the other hand, it is used in cases where joining member is brazed on both sides of the base plate, it is possible to laminate Fe-atom-diffusion-suppressing layer 12, 12 and the brazing filler metal layer 13, 13, on both sides of the base plate 11. Further, if brazing filler metal is to be prepared separately, there is no need to laminate the brazing filler metal layer 13.

[0026] Here, let us explain the result of the corrosion resistance and oxidation resistance study of the brazed structure that brazed using above-mentioned composite material for brazing 1 stated above. The composite material for brazing 1 used for this study used JIS specification SUS304 stainless steel plate (0.4 mm thick) as the base plate 11, and a Fe-atom-diffusion-suppressing layer 12 made from Ni-Cr alloy and a brazing filler metal layer 13 made from pure Cu or Cu-Al alloy were laminated using pressure welding on top of it. For the composite material used for each specimen, Table 1 shows the Cr amount in Ni-Cr alloy of Fe-atom-diffusion-suppressing layer 12, Al amount in Cu-Al alloy in the brazing filler metal layer 13, brazing conditions (temperature, holding time), as well as Ni amount, Cr amount, and Al amount in Cu-Ni-Cr alloy or Cu-Ni-Cr-Al alloy (amount of element is shown in mass %). Although we tried to form the brazing filler metal from Cu-7% Al alloy, this alloy had a poor workability, and could not be made into a plate shape. Thus,

we could not make composite material for brazing from this.

[0027] We produced L-shape composite material piece by bending it into L-shape with the brazing filler metal layer 13 on the outside. A pair of this L-shape pieces were stacked and brazed together with the long side of the L-shape piece overlapping, which produced T-shape brazing structure specimens. We used each of these specimens produced in this manner to measure the average composition of the brazing filler metal with EPMA, and also tested for the corrosion resistance and the oxidation resistance.

[0028] In testing for the corrosion resistance, an imitation condensate liquid, made by imitating the exhaust gas condensate liquid, with the following composition was prepared. Then, after immersing each specimen in 10°C imitation condensate liquid for 500 h, the top surface of the T-shape of the specimen was visually observed. We evaluated ones with no corrosion as excellent (A), ones with surface corrosion area of 20% or less as good (B), and those with surface corrosion area of over 20% as not acceptable (C).

- Imitation condensate liquid composition (pH4.4)

Cl⁻: 20 ppm; SO₄²⁻: 350 ppm; NO₃⁻: 150 ppm; NH₄⁺: 700 ppm; Formic acid: 500 ppm; Acetic acid: 700 ppm.

[0029] On the other hand we tested the oxidation resistance by measuring mass change after holding each specimen in atmosphere at 650°C for 50 hr, and divided them by the top area of T-shaped specimen with the exposed brazing filler metal to obtain the oxidation increase/decrease amount per 1 cm². IF the surface oxide film dropped off in powder form

from the brazing filler metal of the specimen after the test, the powdery oxide film was removed with a brush before taking measurements. In this case, the increase/decrease of the oxidation is expressed as a negative value. If stable oxide film is formed on the surface of the brazing filler metal, the increase/decrease of the oxidation is expressed as a positive value. As for evaluation of the oxidation resistance, we evaluated those with positive oxidation increase/decrease amount which is equivalent to or less than the SUS304 of the base plate (about 1 mg/cm²) as very excellent (AA), those with slightly more increase amount than SUS 304 as excellent (A), those whose oxide film did not peel off but the mass increase is large as good (B), those where oxide film peeled off partially as not acceptable (C), and those with significant peeling of the oxide film as not acceptable (CC). These results are all shown in Table 1.

[0030] [Table 1]

Specimen No.	Fe atom diffusion suppressing layer Cr%	Brazing filler metal layer Al%	Brazing condition		Brazing filler metal composition			Corrosion resistance evaluation	Oxidation resistance	
			Temperature °C	Time min	Ni %	Cr %	Al %		Increase/decrease mg/cm ²	Evaluation
*1	-	-	1180	20	20	-	-	A	-18.5	CC
*2	2	-	1180	20	19	1	-	A	-18.4	CC
*3	5	-	1180	20	18	2	-	A	-10.2	CC
*4	10	-	1180	20	18	8	-	A	-8.8	C
5	15	-	1180	20	18	10	-	A	3.2	B
6	20	-	1180	20	17	12	-	A	2.8	A
7	25	-	1180	20	14	14	-	B	2.0	A
*8	10	-	1100	20	8	5	-	C	-9.48	CC
*9	10	-	1200	20	18	8	-	A	-8.70	C
10	10	-	1250	20	22	10	-	A	3.1	B
11	20	-	1100	40	15	11	-	A	3.0	B
*12	20	-	1250	40	28	18	-	C	1.13	A
21	10	1	1180	20	18	8	1	A	4.3	B
22	10	2	1180	20	18	8	2	A	2.7	A
23	10	3	1180	20	17	8	3	A	0.56	AA
24	10	5	1180	20	16	8	4	A	0.41	AA
25	20	1	1180	20	17	12	1	A	1.12	A
26	20	2	1180	20	17	12	2	A	0.42	AA
27	20	3	1180	20	17	12	3	A	0.30	AA
28	20	5	1180	20	16	12	4	A	0.28	AA

(Note) Specimen No with "*" indicates comparative example, embodiment otherwise.

[0031] From specimen No.1~7 in Table 1, when brazing was conducted at the brazing temperature of 1180°C, sufficiently lower than the heating limit temperature, the embodiments (specimen No. 5~7) of this invention, whose Fe-atom-diffusion-suppressing layer is formed by Ni-Cr alloy containing 15~25% Cr, produced 10~14% of Cr content in the brazing filler metal after relatively short holding time of about 20 minutes, showing that these embodiments possess good corrosion resistance and oxidation resistance. On the other hand, when the Cr content of the Fe-atom-diffusion-suppressing layer is at relatively low level of 10%, we could obtain 10% Cr content in the brazing filler metal with relatively short heating time by raising the brazing temperature to close to the heating limit temperature of 1250°C. It was also possible to obtain practical level of oxidation resistance. No.11 shows further, that even with the brazing temperature of 1100°C, it is possible to obtain good oxidation resistance by forming the Fe-atom-diffusion-suppressing layer from Ni-Cr alloy with high Cr content, and by using relatively long brazing time. Specimens No. 21~28 show that the oxidation resistance improves significantly by using Al-Cu alloy for brazing filler metal containing 1~5% of Al, and especially if it contains 2~5%.

[0032] Next, flow passage structure of heat exchanger is explained where the composite material 11A for brazing of the embodiment of this invention is used.

[0033] Figure 4 is a perspective view showing a flow passage structure of heat exchanger related to the first embodiment. A plurality of pair of plate material 21-1 and 21-2 deployed opposite from each other are

deployed in parallel, separated by prescribed distance. In this example in the Figure, accordion-shape fin member 22 with cross-section of bent wave shape is placed between the lower plate member 21-2 of the upper side pair and the upper plate member 21-1 of the lower side pair deployed at opposite location from this plate member 21-2. Here, above-mentioned plate member corresponds to the first joining member of brazing structure of this invention, while the fin member corresponds to the second joining member.

[0034] The space between above-mentioned pair of plate members 21-1 and 21-2 serves as the flow passage in which the heat exchange medium such as cooling water would flow. On the other hand, many partitioned spaces separated by said fin member 22 between the lower plate member 22-2 of the upper pair and the upper plate member 21-1 of the lower pair would serve as the gas flow passage in which high-temperature corrosive gas such as exhaust gas for heat exchange would flow.

[0035] The top-most convex section of the wave form of each fin member 22 and the lower side of the upper plate member supporting this fin member 22 are brazed via the brazing filler metal, and the lowest concave section of the wave form of each fin member 22 and the top side of the lower plate member 21-1 supporting the fin member 22 are similarly brazed via the brazing filler metal. In the following explanation, when the plate member 21-1 and 21-2 of a pair need not be individually identified, we use notation of 21 for the plate member.

[0036] The material of above-mentioned plate member 21 prior to brazing is made from composite material for brazing having the structure

and material characteristics shown in Figure 1 by cutting it into appropriate size. Above-mentioned fin member 22 are made from thin stainless steel plate similar to the base plate 11 of the composite material for brazing 1 which is made into wave form. For convenience, we will use the same notation for the plate material as above-mentioned plate member 21, and use the same notation for each laminated layer as for the composite material for brazing 1.

[0037] To produce heat exchanger using plate member material 21 and fin member material 22, first assemble the fin member material 22 and the plate member material 21 alternating them and stacking them as shown in Figure 4 so that the fin member material 22 would contact the brazing filler metal layer 13 of the plate member material 21, and hold the shape. Place this assembly in a vacuum or in a reducing gas atmosphere, heat it for about 10~50 minutes at a temperature less than the melting point of Fe-atom-diffusion-suppressing layer 12 and above the melting point of the brazing filler metal layer 13, which normally is 1100~1250°C. This is to obtain 15~25% of Ni content, 10~15% of Cr content (if brazing with Al added Cu-group alloy brazing filler material as mentioned later, use 8~15% content) with Cu for the balance in the brazing filler metal part. With this, the brazing filler metal layer 13 of the plate member material 21 would melt, which in turn would cause the fin member 22 to be brazed to the Fe-atom-diffusion-suppressing metal layer 12, which was pressure welded on the base plate 11, via brazing filler metal containing above-mentioned Ni and Cr amount and possessing favorable corrosion resistance and oxidation resistance. By using Al-containing Cu-group

alloy containing 1~5% Al as Cu brazing filler metal, the brazing filler metal part would also contain almost same level of Al, which can significantly improve the oxidation resistance without deteriorating the corrosion resistance. In this case, good oxidation resistance can be obtained if Cr content is at least 8%.

[0038] Figure 5 is a cross-section view showing a flow passage structure of heat exchanger related to the second embodiment. This flow passage has a honeycomb structure, which is configured from multiple number of laminated layers of concave/convex material 31, which are formed from continuously alternating trapezoid shape concave part 32 and convex part 33. To simplify explanation, notations 31-1 and 31-2 are assigned to a pair of convex/concave members placed next to each other in up/down orientation. Here, the convex/concave member 31-1 and 31-2 would correspond to the first joining member and the second joining member of the brazing structure of this invention.

[0039] The outside (bottom side) of concave section 32 of upper wave-form member 31-1 and the outside (top side) of convex section 33 of lower wave-form member 31-2 of adjacent convex/concave members 31-1 and 31-2 are brazed to each other. With this, multiple spaces are formed with hexagonal cross-section between the convex section 33 of upper member 31-1 and the concave section 32 of the lower member 31-2. These spaces serve as gas flow passage G for high-temperature corrosive gas such as exhaust gas and medium flow passage W for heat exchange medium such as cooling water. In the figure, alternate gas flow passage G and medium flow passage W are deployed from left to right.

[0040] The material of above-mentioned concave/convex member 21 of said heat exchanger is made from composite material for brazing 1A having the structure and material characteristics shown in Figure 2 by cutting it into appropriate size with concave/convex shape. For convenience, we will use the same notation for the concave/convex member material as above-mentioned concave/convex member 31, and use the same notation for each laminated layer as for the composite material for brazing 1A.

[0041] To produce heat exchanger using said concave/convex member material 31, stack the bottom plate 32 of upper concave/convex member material 31-1 and the top plate 33 of lower concave/convex member material 31-2 and laminate as shown in Figure 5. This is heated and held in a vacuum or a reduction gas environment as was with the first embodiment. With this, the brazing filler metal layer 13 and 13 of the concave/convex member material 31-1 and 31-2 deployed opposing from each other are melted and integrated, and are brazed to each other via a brazing filler metal containing prescribed amount of Ni, Cr, and Al.

[0042] The interpretation of the brazing structure of this invention should not be limited in any way by the flow passage structure of the heat exchanger of the first and the second embodiments. For example, the number of laminated layers in the plate member 21 of the first embodiment, as well as the number of laminated layers of concave/convex member 31 of the second embodiment, could be set freely according to the needs. Further, although we used stainless steel thin plate for the fin member 22 in above first embodiment, it is possible to use those with laminated Fe-atom-diffusion-suppressing layer on base plate of stainless steel thin

plate, or to use those with brazing filler metal layer formed on Fe-atom-diffusion-suppressing layer as was in Figure 1. With respect to the fin member, by forming Fe-atom-diffusion-suppressing layer, it is possible to prevent diffusion and invasion of melted Fe atoms from the base plate of the fin member to the brazing filler metal part, thereby preventing deterioration of corrosion resistance of the brazed section having brazed fin member.

[0043] Further, regarding the flow passage structure of heat exchanger under the first and second embodiments, the composite material for brazing 1 and 1A used as their material had Fe-atom-diffusion-suppressing layer 12 as well as the brazing filler metal layer 13 bonded together. However, the brazing filler metal layer 13 is not necessarily needed. In this case, separately prepared Cu brazing metal should be placed between the plate member material and the fin member, or between the concave/convex member materials, and braze them.

[0044] [Advantage effect of the invention]

Since the composite material for brazing under this invention has Fe-atom-diffusion-suppressing layer made from Ni-Cr alloy with Ni as the chief ingredient and containing 10~30% Cr, it is possible, when the joining member is brazed with Cu brazing filler metal, to suppress diffusion of Fe atoms which otherwise would weaken the corrosion resistance of the brazing filler metal part, and to easily diffuse appropriated amount of Ni and Cr. Thus, it is possible to improve the corrosion resistance and the oxidation resistance of the brazing filler metal part. For this reason, by configuring flow passage of heat exchanger that is used under

high-temperature corrosive environment such as exhaust gas by using the composite material for brazing of this invention, its durability can be improved.

[Brief description of drawings]

[Figure 1] A partial cross-section view of the composite material for brazing under an embodiment of this invention.

[Figure 2] A partial cross-section view of the composite material for brazing under another embodiment of this invention.

[Figure 3] A cross-section view of brazing structure in T-shape that was used for testing the corrosion resistance and oxidation resistance characteristics.

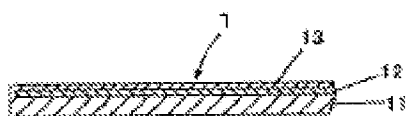
[Figure 4] A partial cross-section view of the flow passage structure of heat exchanger relating to the first embodiment of the brazing structure of this invention.

[Figure 5] A partial cross-section view of the flow passage structure of heat exchanger relating to the second embodiment of the brazing structure of this invention.

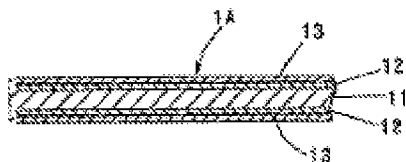
[Description of codes]

1, 1A ... Composite material for brazing;
11 ... Base plate;
12 ... Fe-atom-diffusion-suppressing layer;
13 ... Brazing filler metal layer;
21-1, 21-2 ... Plate member;
22 ... Fin member;
31 ... Concave/convex member;

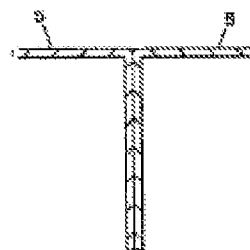
[Figure 1]



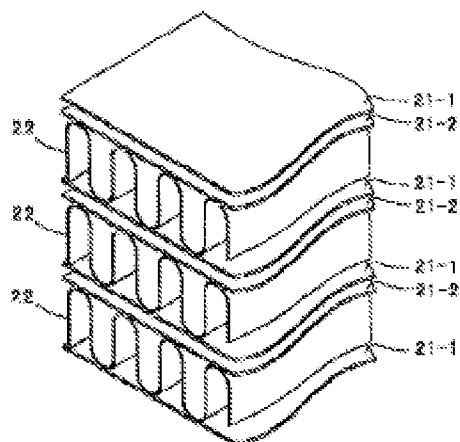
[Figure 2]



[Figure 3]



[Figure 4]



[Figure 5]

